SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1910.

GENERAL PHYSICS.

782. *Alteration of the Compressibility on Softening of an Amorphous Substance.* **A. D. Cowper and G. Tammann.** (Zeitschr. Phys. Chem. 68. 3. pp. 281–288, Dec. 7, 1909.)—The method employed by the authors for measuring the compressibilities of liquid and solid substances consists in determining the distance through which a piston fitted to a steel cylinder containing a liquid must be moved in order to increase the pressure by a known amount. The cylinder is connected with a cylindrical vessel which contains the substance to be examined, and which is itself connected with a manometer. In order to avoid appreciable passage of the liquid between the piston and cylinder a very viscous liquid must be employed; the author's experiments were made with castor oil. At constant pressure the compressibility of castor oil increases linearly with rise of temperature, whilst at constant temperature it diminishes considerably as the pressure is increased. The compressibility of crystalline dextrose depends only to a slight extent on pressure and temperature, whilst that of amorphous dextrose is about double that of the crystalline sugar, and increases linearly with rise of temperature and diminishes slightly with increase of pressure. With rise of temperature the viscosity of amorphous dextrose diminishes very rapidly, and the same is the case with amorphous betol. This great change of the internal friction with the temperature corresponds in neither case with alteration of the expansion, the volume-isobars being rectilinear. T. H. P.

783. *Effect of Temperature on the Torsional Elasticity of a Metal.* **F. Meissner.** (Akad. Wiss. Wien, Sitz. Ber. 118. 2a. pp. 1131–1152, Oct., 1909.)—The alteration of torsional elasticity of a metal with temperature has been experimentally determined by many investigators, but so far little or no work has been carried out at temperatures above 300° C. The author experimented on wires of Ni, Fe, and Ag of diams. varying from 0·05 mm. to 0·5 mm., at temperatures up to 500° C. in the case of the small wires, and to about 750° C.

for the larger wire. Two methods of experiment were adopted. In the first the specimen wire (15 cm. long) was suspended midway in a porcelain tube (115 cm. long) by having an iron wire (2 mm. diam.) attached to its upper extremity, and a second iron wire (1 mm. diam.) to its lower extremity. This latter wire carried a small mirror and an "inertia" bar consisting of a copper wire carrying two vertical plates (farthings) at its extremities. The whole was contained in suitable tubes, which were exhausted by an automatic vacuum pump. Heating was obtained by surrounding the porcelain tube in the neighbourhood of the specimen with nickel wire, through which a current was passed. Temperatures were measured by means of a Constantan-Fe couple graduated in a similar apparatus used for the experiment proper. The inertia bar being set in motion by repelling one end with an electrified rod the elastic properties of the wire were deduced from the periodic time of vibration and the log. decrement as observed by the mirror. The second method, which was used for the larger wires, was similar to the first, but in this case heating was produced by passing a current through the specimen itself and deducing the temperature by measuring the change in resistance, due correction being made for any disturbing factors. The results are set forth both in tables and curves, giving the change in torsion modulus and log. decrement. The results are too irregular to express without curves, but it may be stated that the change-point in iron in the neighbourhood of 800° C. is marked by rapid changes in the log. decrement. The curves for Ag previously obtained by Pisati are shown plotted for comparison.

C. A. M. S.

784. *Nickel Steel Riveted Joints.* **E. Preuss.** (Iron and Steel Inst., Carnegie Schol. Mem. 1. pp. 60–142, 1909. Mech. Eng. 28. pp. 749–750, June 11, 1909.)—Tensile tests of Ni-steels up to 600° C. showed higher yield-points and ultimate strength than are possessed by wrought iron at the same temperatures. Heating at temperatures up to 1040° did not appreciably decrease the resistance of the nickel steels to shock. The ultimate strength of Ni-steel riveted joints was from 2 to 2¼ times as great as that of wrought-iron riveted joints. Electric furnace Ni-steel, though possessed of high ultimate shear strength, was found to be rather brittle. About 25 per cent. greater pressure was needed in shaping the heads of Ni-steel than of iron rivets. The author considers the ultimate shear strength of the joint to be of greater significance than the resistance to slip. Part of the slip occurred before the working load was reached. Thin plates have greater resistance to slipping than thick plates. The resistance to slipping was the same with Ni-steel as with wrought-iron rivets. Greater slip occurred in butt joints than in lap joints of the same ultimate strength. The resistance to slip was increased by fullering the edges of the plates, and still more by fullering the rivet heads. The tendency to slip was about constant for all methods of riveting (hand, hydraulic, electro-hydraulic, pneumatic press, pneumatic hammer), but varied considerably according to the condition of the contiguous plate surfaces. Fewer and smaller rivets of nickel steel may, it is concluded, be used, more than compensating for the higher cost of the material.

P. R.

785. *Elastic Limit of Manganese and other Bronzes.* **J. A. Capp.** (Amer. Soc. Mech. Engin., Journ. 32. pp. 878–884, March, 1910. Mech. Eng. 25. pp. 613–616, May 20, 1910.)—The object of the paper is to show that while the yield-point for steel is so well marked in properly conducted tests, and bears a sufficiently definite relation to the true elastic limit to warrant the dependence placed upon it by the engineer, there is no equally well-defined point found in testing bronzes, and the value commonly obtained from rapid commercial tests as the elastic limit or yield-point on bronze may be quite misleading. Manganese bronze was selected for the tests. The author considers that the results, so far as tensile tests are concerned, may be taken as typical of brasses and bronzes in general. Specimens tested were about 12 in. long over all, 1 in. diam., and 8 in. between gauge points, and screwed ends 1½ in. diam. Some were tested at Halcomb laboratory to obtain autographic strain diagrams. Others were tested with extensometer in the laboratory of the General Electric Co., and others on machine at Watertown Arsenal. The original bars were 24 in. long, and test-pieces ½ in. by 2 in. were turned and tested in the customary commercial way, using a pair of multiplying dividers to note yield-point. Typical sets of readings and curves are given. Accepting the elastic limit as value of stress beyond which Hook's law no longer holds, the author finds its value for bronzes tested is from 16,000 to 28,000 lbs. per sq. in., whereas the yield-points found for cast metals ran from 25,000 to 29,000 lbs., and for worked metals from 30,000 to 44,000 lbs. per sq. in. Had ordinary dividers been used the values for the cast metals would have been placed between 30,000 and 40,000 lbs. per sq. in. Autographic diagrams from commercial "structural medium" steel and the bronzes tested are contrasted. No dependence can be placed upon the so-called yield-point as determined upon bronzes, and the author advises recourse to the slower but more accurate determination of the true elastic limit. Hot-working of the metal has not materially improved its elastic properties, but has greatly increased its toughness, and probably in an extended series of tests would have been found to impart uniformity. Neither hot nor cold working cause any change in the elastic curve of the metal; it remains a characteristically smooth curve. C. A. M. S.

786. *Tests on Concrete Columns made under Building Conditions.* **H. C. Berry.** (Eng. Record, 61. pp. 206–209, Feb. 19, 1910.)—Nine columns 14 in. square and 12 ft. high were tested in the engineering laboratories of the University of Pennsylvania. Triplicate tests were made of three types of columns, (1) plain concrete, (2) concrete and longitudinal reinforcement, (3) concrete and spiral hooping in addition to the longitudinal reinforcement. Tests were made on a 600,000-lb. Olsen four-screw testing machine, lead plates being used at ends. Load was applied at rate of about 100 lbs. per sq. in. per min., and readings taken of deflection and compression at loads of 500, 1000, and in most cases 1500 lbs. per sq. in., and the permanent set noted. Values and curves, and the constants of columns and results are given in tables. The average strength of plain columns is about 2500 lbs. per sq. in.; longitudinal reinforced columns with 1·15 per cent. reinforcement, 2580 lbs. per sq. in. —increase of 3·2 per cent.; that of hooped columns with 2·4 per cent. reinforcement, 2810 lbs. per sq. in.—an increase of 12·4 per cent. Uniformity of individual results is shown by the difference between highest and lowest plain columns, which is 17·6 per cent. of average strength. For the longitudinally reinforced column the figure is 8·5 per cent.; for hooped ones 6·4 per cent. The values obtained by the formula $P = Af_c[1 + (n - 1)p]$ agree with max. loads to within 10 per cent. for the reinforced columns, if $f_c = 2500$ and $n = 10$, with the values obtained from tests on plain columns and cylinders. Photographs show the characteristic method of failure of the different types of

columns. The conclusions arrived at are that plain concrete gives good results; increase of strength by reinforcement is small. The notion that hooped columns are much more desirable because of greater toughness is considered ill-founded, because this toughness is not exhibited until after the max. load is developed. C. A. M. S.

787. *Testing of Heated "Grog-bricks" under Pressure.* **M. Gary.** (Königl. Materialprüfungsamt, Mitt. 28. pp. 23–40, 1910.)—The specimens were heated by means of an electric furnace capable of raising the temperature to about 1200° C. Temperatures were measured by two le Chatelier pyrometers, and a considerable number of preliminary experiments are described in order to determine the rate of heating and cooling. The specimens for testing under heat were cylinders 5 cm. diam. and 5 cm. in height, the method of applying the load being clearly illustrated. As an example, details of a series of tests on stone described as "Rheinische Steine des Handels" are given. As a result of 10 tests (cold) on two specimens approximately 25·0 × 12·4 × 14·9 cm. cemented together, a mean breaking pressure of 195 kg. per sq. cm. was obtained. Testing with cylindrical specimens 5 cm. diam., 5 cm. high, the breaking stress was 169 kg. per sq. cm. cold and 218 kg. per sq. cm. at 1000° C. Results are also given as to the expansion of specimens after being heated to 1200° or 1300° C. and cooled down again. This expansion seems very small, the average increase with cylindrical specimens so treated being only 0·1 mm. increase of diam. in 50 mm. C. A. M. S.

788. *Terminal Velocity of Spheres falling in a Fluid.* **E. Cunningham.** (Roy. Soc., Proc. Ser. A. 83. pp. 357–365, March 2, 1910.)—Recent investigations have called attention to the question as to how closely the rate of fall of particles through a fluid when very small, approximates to that given by the law obtained by Stokes from hydrodynamical reasoning. This paper deals theoretically with two of the main sources of divergence from that law. Firstly, taking the particles to be smooth spheres moving through a gas, it is shown that the deviation to be expected on account of the diam. of the particle being small, compared with the molecular free path, is extremely small for such particles as have been experimented with; and a modified formula is given which may be taken to hold approximately for lower pressures or for particles of smaller dimensions. Secondly, an approximate treatment is made of the effect of the simultaneous presence of a large number of particles moving with the same velocity through the fluid, and it is found that the force required to maintain the motion of one of these depends not only on the diam., but on the ratio of the diam. to the distance between the particles, and in such a way as to increase rapidly as this ratio increases beyond the value 0·1. With the figures obtained by J. J. Thomson in 1903, it is shown that these corrections together would imply an increase of not more than $0{\cdot}07 \times 10^{-10}$ in the charge on the gaseous ion—that is, an increase of about 2 per cent. E. H. B.

789. *Air-resistance.* **P. Burgatti.** (Accad. Lincei, Atti, 19. pp. 867–878, April 3, 1910.)—The resistance experienced by a thin plane surface moving through air depends upon breadth a (normal to direction of motion), length b, inclined to direction of motion by angle θ, as well as the pressure p and density ρ of the air. The most general expression for the resistance is therefore $R = f(a, b, \theta, v, p, \rho)$. The author attempts to bring this formula down to experimental data. He substitutes the "extension" (allungamento) l for a/b, and puts σ for the area ab. Since R, p, and ρ are the only quantities involving mass, the resistance must be a linear homogeneous function of these. The velocity of sound $u = (\sigma_0 p/\rho)^{\frac{1}{2}}$, where σ_0 is a constant of the dimensions of a surface. Since R, v, and u are the only quantities depending upon time, R must be a quadratic homogeneous function of u and v. Finally, since l, θ, and $w = (\sigma/\sigma_0)(u/v)^2$ have zero dimensions, the final formula is $R = K(l, \theta, w)\rho\sigma v^2$. This shows that the coefficient of resistance K, which in Newton's formula is constant, depends upon the extension, the inclination, and the "specific ratio" w. This triple variability remains to be determined experimentally. E. E. F.

790. *The Principle of Relativity in Mechanics and Electrodynamics.* **P. Frank.** (Akad. Wiss. Wien, Sitz. Ber. 118. 2a. pp. 373–446, April, 1909.)—There are two ways of establishing the fundamental equations of physical processes. The "mechanistic" theory is based upon intuitions involving certain hypothetical elements. The "conceptual" (sometimes called "energetic") theory is less graphic and intuitive, but has the advantage of being limited to observable quantities. The theorems of the latter are energy theorems or minimum principles. To these the work of Einstein and Minkowski has added the principles of relativity, which (roughly) assert that physical processes in a system are not changed when the system moves rectilinearly as a whole with constant velocity. Mathematically these principles are represented by an invariance or co-variance with respect to certain transformations. These transformations are (1) for Newtonian mechanics the "Galilean transformation":

$$x' = x - at\,;\ y' = y\,;\ z' = z\,;\ t' = t\,;$$

(2) for Lorentz's electrodynamics the "Lorentz transformation":

$$x' = (x - at)/\sqrt{(1 - a^2)}\,;\ y' = y\,;\ z' = z\,;\ t' = (-ax + t)/\sqrt{(1 - a^2)}.$$

Einstein and Minkowski substitute the Lorentz transformation for the Galilean in order to establish systems of electrodynamic mechanics. This is done in a more rigid form in the present work. It is shown that a system of electromagnetic mechanics, *i.e.*, a system in which the Lorentz-Einstein relativity theorem prevails instead of the Newtonian, may be built up simply by taking all definitions and axioms bodily from the classical mechanics and replacing everywhere the Galilean by the Lorentz transformation. The relativity theorem of Newtonian mechanics may be put in the form: If a body S can be regarded as absolutely at rest, then every body moving uniformly and rectilinearly with regard to S may also be regarded as absolutely at rest. In the electromagnetic system of mechanics the absolute distance between two material points is increased with respect to the empirical distance in the ratio $1 : \sqrt{(1 - v^2)}$ when the system moves in the x-direction with a velocity v. This velocity being arbitrary, the ratio between empirical and "absolute" distance is also arbitrary. The fact that the empirical distances in a system, as compared with the absolute distances are the smaller the quicker the displacement of the system in absolute space, is designated as the [Fitzgerald-] Lorentz contraction. This is, therefore, not a real contraction in the ordinary sense, but an expression for the method of delineation in absolute space. When it is concluded from Lorentz's theory that the earth contracts by its motion in the ratio

$1 : \sqrt{(1 - v^2)}$, v signifies the velocity of the earth with respect to the sun. We delineate the occurrences in absolute space in such a manner that the delineation of the sun is at rest. This is necessary in order to bring the electromagnetic and mechanical occurrences which empirically happen at the same place into coincidence in their delineations in absolute space. The electrodynamical principle of relativity asserts that if a system S may be regarded as absolutely at rest, the same assumption may be made with regard to a system S′ which has a uniform rectilinear motion with respect to S. Mathematically, this signifies the co-variance of the equations for a refractionless body with regard to the Lorentz transformation. The principle may be used as an axiom for establishing new equations. E. E. F.

791. *Rigid Bodies and Relativity.* **F. Noether.** (Ann. d. Physik, 31. 5. pp. 919-944, April 5, 1910.)—In the electrodynamic system of mechanics founded by Lorentz, Einstein, and Minkowski the invariance of natural laws is postulated with regard to that linear transformation of space and time co-ordinates which leaves the velocity of light in a vacuum unchanged. In accordance with this system Born [Abstract No. 1728 (1909)] put forward a definition of a rigid body which makes its dimensions, as perceived from a system of co-ordinates moving with respect to it, depend upon the relative velocity of the body and the system. Born's definition covers accelerated translations. A motion is the translation of a rigid body when the Lorentz transformation which transforms one of its points to rest, also transforms all its other points to rest. The author shows that this translation may be made to include uniform rotation so long as the four-dimensional distance between two points, $r^2_{12} = (x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 - c^2(t_1 - t_2)^2$, remains unchanged. Accelerated rotations, or rotations about accelerated points, are not admissible. E. E. F.

792. *Diurnal Variation of Temperature in the Free Atmosphere at* 1 *and* 2 *km.* **E. Gold.** (Akad. Wiss. Wien, Sitz. Ber. 118. 2a. pp. 1207-1236, Oct., 1909.)—The data discussed are those obtained with kites and kite-balloons at Berlin-Lindenberg, 1903-1907, and at Pavlovsk 1902, 1903. Seeing that the ascents are neither very numerous nor distributed uniformly over the 24 hours, the calculation of the average of all results available for each hour would be influenced to a considerable extent by accidental circumstances such as the prevailing weather, the time of year, &c. To avoid this source of error the differences have been found between the temperatures observed at heights of 1 and 2 km. and the mean temperature at the surface for the 24 hours in the middle of which the ascents were made. These differences were then meaned for each hour, after suitable correction for changes of temperature independent of diurnal variation. The investigation showed the existence of a 24-hour period variation of temperature in the free atmosphere above both Berlin and Pavlovsk, of amplitude 1·7° C. at 1 km. and 1·3° C. at 2 km. The extremes occur nearly 5 hours earlier at 2 km. than at 1 km. The semi-diurnal (12-hour) terms are of much smaller amplitude, (0·28 ± 0·20)° C. at 1 km. and (0·50 ± 0·46)° C. at 2 km. R. G. K. L.

793. *Temperature Conditions of the Free Atmosphere.* **A. Wagner.** (Meteorolog. Zeitschr. 27. pp. 97-112, March, 1910. Extract from Beiträge zur Physik der freien Atmosphäre, Vol. 3, Nos. 2 and 3.)—The paper summarises and discusses the data contained in the publication of the International

Commission for Scientific Aeronautics for the period July, 1902, to June, 1907. Only the results of ascents made with registering balloons which reached an altitude of 8 km. are considered. After eliminating all ascents of which the accuracy is acknowledged to be doubtful, there remain 380 ascents. The first section deals with the average temperature and its annual variation at heights up to 16 km. The results for each level have been analysed harmonically. The coefficients are as follows :—

$$\begin{array}{lll}
\text{Ground } t = & +\ 7{\cdot}90 + 9{\cdot}37 \sin(261{\cdot}7^\circ + x) & + 0{\cdot}88 \sin(345^\circ + 2x) \\
1 \text{ km.} & +\ 4{\cdot}62 + 8{\cdot}15 \sin(256{\cdot}3 + x) & + 0{\cdot}91 \sin(28 + 2x) \\
2\ \text{''} & +\ 0{\cdot}06 + 6{\cdot}95 \sin(251{\cdot}6 + x) & + 1{\cdot}19 \sin(52 + 2x) \\
3\ \text{''} & -\ 4{\cdot}95 + 6{\cdot}76 \sin(248{\cdot}2 + x) & + 1{\cdot}29 \sin(63 + 2x) \\
4\ \text{''} & -10{\cdot}66 + 7{\cdot}00 \sin(247{\cdot}8 + x) & + 1{\cdot}18 \sin(69 + 2x) \\
5\ \text{''} & -16{\cdot}89 + 7{\cdot}35 \sin(245{\cdot}8 + x) & + 1{\cdot}58 \sin(64 + 2x) \\
6\ \text{''} & -23{\cdot}71 + 7{\cdot}66 \sin(245{\cdot}5 + x) & + 1{\cdot}24 \sin(76 + 2x) \\
7\ \text{''} & -30{\cdot}75 + 7{\cdot}84 \sin(245{\cdot}5 + x) & + 1{\cdot}36 \sin(89 + 2x) \\
8\ \text{''} & -38{\cdot}01 + 7{\cdot}82 \sin(244{\cdot}2 + x) & + 1{\cdot}22 \sin(85 + 2x) \\
9\ \text{''} & -44{\cdot}41 + 6{\cdot}84 \sin(245{\cdot}8 + x) & + 0{\cdot}98 \sin(82 + 2x) \\
10\ \text{''} & -49{\cdot}61 + 5{\cdot}59 \sin(250{\cdot}1 + x) & + 0{\cdot}81 \sin(58 + 2x) \\
11\ \text{''} & -52{\cdot}88 + 4{\cdot}57 \sin(261{\cdot}4 + x) & + 0{\cdot}57 \sin(325 + 2x) \\
12\ \text{''} & -54{\cdot}18 + 4{\cdot}28 \sin(276{\cdot}8 + x) & + 0{\cdot}55 \sin(331 + 2x) \\
13\ \text{''} & -54{\cdot}45 + 4{\cdot}06 \sin(273{\cdot}5 + x) & + 0{\cdot}21 \sin(97 + 2x) \\
14\ \text{''} & -54{\cdot}42 + 4{\cdot}16 \sin(275{\cdot}5 + x) & + 0{\cdot}70 \sin(79 + 2x) \\
15\ \text{''} & -54{\cdot}28 + 4{\cdot}25 \sin(277{\cdot}9 + x) & + 0{\cdot}98 \sin(82 + 2x) \\
16\ \text{''} & -54{\cdot}05 + 4{\cdot}42 \sin(278{\cdot}0 + x) & + 0{\cdot}87 \sin(61 + 2x)
\end{array}$$

The second part of the paper discusses the annual variation of the temperature t_i at the commencement of the "isothermal layer," and of H_i, the level, in km., of its commencement. The following table gives the results (1) as obtained directly from the observations ; (2) as given by harmonic analysis of the results. [Temperatures are on the Centigrade scale] :—

	No. of Observations.	Raw Monthly Mean.		From Harmonic Analysis.	
		t_i.	H_i.	t_i.	H_i.
January	14	− 61·4	10·5	− 59·5	10·34
February	18	− 59·7	10·2	− 59·2	9·96
March	24	− 55·8	9·4	− 57·5	9·69
April	29	− 55·5	9·8	− 55·8	9·79
May	22	− 55·4	10·5	− 53·8	10·25
June	26	− 52·0	10·6	− 53·1	10·79
July.................	16	− 52·9	11·0	− 53·1	11·08
August	34	− 54·2	11·3	− 53·2	11·02
September.........	15	− 52·7	10·5	− 53·6	10·79
October	21	− 54·6	10·7	− 54·5	10·68
November	18	− 57·7	10·8	− 56·3	10·61
December	26	− 55·8	10·2	− 57·7	10·57
Year	263	− 55·6	10·46	− 55·6	10·46
Range...............	—	9·4	1·9	6·4	1·39

The third section discusses the influence of variations of climate, separate tables being given for Central, Northern, Eastern, Southern, and Western Europe. The fourth section deals with the influence of different types of weather. R. G. K. L.

794. *Unusual Halo Phenomenon.* **L. Besson.** (Comptes Rendus, 150. pp. 426–427, Feb. 14, 1910.)—A peculiar form of halo was observed from the Montsouris Observatory, Paris, at intervals between 2.10 p.m. and 3.30 p.m. on Feb. 5, 1910. The mean value of the radius was found to be 40° 8′. The width was about 8°, colour white with a light rose tint along the external edge, and a violet tint along the internal edge. At the time of greatest brilliancy a dark band, 2° 30′ wide, was noted on the inner side. The sky was covered almost entirely by a layer of fibrous high cloud (alto-stratus, alto-cumulus, and cirro-cumulus). Towards the north two cloud layers could be distinguished. The lower layer obscured the halo, proving that the latter was produced by the upper layer. The great altitude of the layer giving rise to the optical effects, makes it probable that the cloud consisted of ice particles rather than of water droplets. Hence the phenomena must be classed as a halo and not as a corona. Probably it was an example of Bouguer's halo. R. G. K. L.

795. *The Squall of October* 4, 1908. **S. Landin.** (Ark. för Mat. Astron. och Fysik, 6. 11. pp. 1–7, 1910.)—On Oct. 4, 1908, a typical line-squall passed across Southern Sweden. The squall is first identified at 11 a.m. over Central Sweden, about 300 km. NW. of Upsala. A series of isochronous lines, running roughly from SW. to NE. mark its further progress to the south eastward. The average rate of advance was 65 km. per hour. At 8 p.m. the squall passed on to the Baltic, and the author has not been able to trace its further progress through lack of observations. The barograph records show a brisk fall of pressure up to the time of occurrence of the squall, a sudden upward kick of about 1 mm. at the time of the squall, followed by a steady barometer. In front of the isochronous lines we find a region of SW. winds, in which temperatures as high as 22° C. = 72° F. occurred. As the squall passed, temperature fell to about 10° C. = 50° F. Heavy rain or hail accompanied the squall. At Upsala, where the weather during the early part of the day had been remarkably fine, rain commenced a few minutes after the squall broke. The strong squall winds blew from between west and north, as was shown by the directions of uprooted trees. Very remarkable is the manner in which the damage done by the wind was localised. At Fiskartorpet, near Stockholm, a narrow tract of country only 40 m. wide and 250 m. long was almost stripped of trees. This "lane" ran from WNW. to ESE., *i.e.*, nearly at right angles to the isochronous lines marking the progress of the squall. A similar narrow "lane" of destruction, measuring 500 × 50 m.^{2}, was cut out at Marielund, 15 km. east of Upsala. In this case the "lane" ran from NW. to SE., and the trees fell to SE. The limit of the destructive wind was exceedingly well defined. A tree situated on the edge of the area of destruction had its one side stripped of leaves while the other was undamaged. R. G. K. L.

796. *Sun-spots of September* 25, 1909. **F. Slocum.** (Astrophys. Journ. 31. pp. 28–29, Jan., 1910.)—Several notable sun-spot groups were present on the sun at the time of the great magnetic storm of Sept. 25, 1909, and their chief characteristics are here described. As reported by J. E. Burbank [see Abstract No. 447 (1910)], the disturbance lasted from 11h. 39m. a.m. to 9h. p.m. G.M.T. The calcium plates taken with the Rumford spectroheliograph, both before and after local noon, show a moderate amount of activity in the area around the large spot, and in the region between a pair of smaller ones. A series of exposures taken before noon indicate no apparent change, but a plate exposed 2 hours after noon shows a new eruption on the NW. edge of the penumbra. With the idea that the source of the magnetic disturbance lies with the large spot, the history of the group is given from Sept. 1. C. P. B.

797. *Displacements of Spectrum Lines at Sun's Limb.* **W. S. Adams.** (Astrophys. Journ. 31. pp. 30–61, Jan., 1910.)—In 1907 Halm announced the detection of small displacements of the solar spectrum lines at the sun's limb which were independent of the motion of rotation; the results of an investigation of two iron lines indicated a displacement towards the red of +0·012 Å.U., while an enhanced line of iron at λ6516 showed no displacement. These shifts were ascribed to the greater effective pressure in the sun's reversing layer at the limb than at the centre. When this work was taken up at Mount Wilson by Hale and Adams, it was found that the whole solar spectrum was modified at the limb [Abstract No. 1465 (1907)]. Buisson and Fabry examined the phenomenon with interference apparatus, and found that the displacements are due to the widening of the lines on their red edges, the violet edges retaining their normal positions. From a very extensive series of measures Adams now gives a preliminary discussion of the results. He concludes that (1) the lines of hydrogen, H, K, and 4227 of calcium, D of sodium, and the *b* lines of magnesium show no appreciable displacement. (2) The displacements for Ti, V, and Sc are considerably smaller than those for Fe and Ni. (3) The lines of the elements of very high atomic weight, such as La and Ce, show very small displacements. (4) The lines of the cyanogen flutings are shifted by small but appreciable amounts. (5) A few lines are unmistakably shifted towards the ultra-violet, the most pronounced of these being the Ti line at λ4527·490. (6) The lines which are considerably strengthened at the limb usually show small displacements. (7) The enhanced lines as a class show decidedly larger shifts than the arc lines. Comparisons of laboratory spectra with those of the sun favour the idea that these displacements may be due to pressure. In the laboratory the entire mass of vapour under examination is under the same pressure, while in the sun there is a pressure gradually increasing downward throughout the strata, whose absorption produces the dark lines. The result is that the lines are widened towards the red. C. P. B.

798. *Envelopes of Comet Morehouse.* **A. S. Eddington.** (Roy. Astronom. Soc., M.N. 70. pp. 442–458, March, 1910.)—One of the most striking features shown on the photographs of Comet Morehouse (1908*c*) is the clear definition of the parabolic envelopes which often appeared in or near the head of the comet. Moreover, these envelopes showed evidence of very rapid change, and a close study of them revealed a very complex constitution. The photographs were measured with a low-power eyepiece in a position micrometer; determinations of the focus, vertex, and directrix were made, giving two independent values of the focal length of each envelope. From the fountain theory it is shown that when a great number of particles are projected from a point with equal velocities under gravity, the envelope of their paths is a paraboloid, having the point of projection as focus. In the case of comets it is the sun's repulsive force which takes the part of gravity. It is thus evident that the envelope is composed of different particles at successive instants, and in Comet Morehouse an excellent opportunity was presented of studying these rapid changes. From a close study of the measures it is found that soon after its formation an envelope always collapses; in no case was an envelope found to expand. Where several envelopes exist simultaneously they may be regarded as showing successive stages of similar outbursts. A most interesting part of the discussion is that leading to the possible values of the repulsive force, and its relation to the gravitational attraction. This ratio appears to vary from 180 to 19,000, being thus enormously greater than had been previously supposed from measures of the tail material of comets. Brédikhine gave the value 86, Jaegermann 80, while direct measures on the tail particles of Comet Morehouse gave values ranging from 100–800. These results show that the repulsive forces acting on the envelope material are greater still. On Oct. 18, the night when there was the best example of the rapid formation of an envelope, there was a well-defined portion of matter which had been projected towards the sun. Adopting the repulsive forces thus determined, the initial velocity is found to be of the order of 10–100 km. per sec. C. P. B.

799. *Motion of Second Satellite of Uranus.* **O. Bergstrand.** (Ark. för Mat. Astron. och. Fysik, Stockholm, 6. 6. pp. 1–19, 1910.)—The observations published from 1894–1901 are discussed for determining a more accurate value of the satellite's motions. The mean value of the eccentricity is given as $e = 0{\cdot}008 \pm 0{\cdot}001$. The semi-major axis comes out as $a = 19{\cdot}08'' \pm 0{\cdot}08''$. The deduced mass of Uranus is then $\mu = 1/288{\cdot}0$ and the density $D = 0{\cdot}16$. C. P. B.

800. *Spectrum of Comet* 1910*a.* **H. Deslandres and P. Idrac.** (Comptes Rendus, 150. pp. 653–655, March 14, 1910.)—In continuation of previous papers [Abstract No. 380 (1910)] the present article describes the results obtained with the slit spectrograph employed for photographing the spectrum of the comet. An objective of 10 cm. aperture and 80 cm. focal length was used to give an image of the comet on the spectroscope slit. Two prisms were used, with a collimator 0·30 m. and camera 0·12 m. focal length. Provision was made for rotating the spectroscope around the axis of the collimator, so as to adjust the slit on the tail or the nucleus of the comet. An excellent negative was obtained on Jan. 29 with an exposure of about 45 min., the cometary spectrum extending from λ500 to λ380. The nucleus shows a continuous spectrum with sharp condensations, wave-lengths for which are given in the paper. Analysis of these confirms the results previously announced from the examination of the prismatic camera photographs—the comet presented the complete spectra of hydrocarbons and cyanogen. C. P. B.

801. *On a New Binary Progression of the Planetary Distances, and on the Mutability of the Solar System.* **H. Wilde.** (Phil. Mag. 19. pp. 597–605, April, 1910. Paper read before the Manchester Lit. and Phil. Soc.)—Reference is made by the author to his previous paper, on his demonstration and discovery that the moving force of celestial bodies is as the square of the velocity and inversely proportional to the square of the distance [see Abstract No. 1388 (1909)]. The author has adopted in his table of planetary orbits the radius vector of Mercury as the most natural and convenient unit to which the other planetary distances should be referred, the terrestrial unit being an obvious survival of the geocentric system of the universe. The change in the unit of distance has revealed a new binary progression of the planetary distances, much nearer the observations than that of Bode's law, and removes the principal ground of objection made by some astronomers to rank the binary progression as a law of nature. The author has demonstrated that the anomalous minus distance of Neptune from the progression is caused, primarily, by its outermost position in the planetary system, with the consequent united attractions of all the planets upon Neptune. The inevitable effect of the outermost position of a planet to contract continuously its radius vector has never presented itself to Lagrange, Laplace, and other writers on celestial mechanics who have elaborated the doctrine of the absolute stability of the solar system. The author has further demonstrated that the final effect of the continuous contraction of an outermost planet would be to cause all the planetary bodies to coalesce in succession to form one or more self-luminous bodies revolving round the sun as binary or ternary revolving stars, of which upwards of 10,000 have been discovered during the last century. A. P. H.

802. *Nebulous Region near ρ Ophiuchi.* **E. E. Barnard.** (Astrophys. Journ. 31. pp. 8-14, Jan., 1910.)—Examination of photographs taken with a small lantern lens shows the existence of several peculiar nebulæ. One of these, involving the star ν Scorpii, exhibits several remarkable features, the chief of which is the apparent veiling of the stars by the nebulous matter. The line of demarcation between the rich and poor regions of sky is too abrupt to be due to any real diminution of the stars. This fact also suggests that the nebula is nearer the solar system than the stars. C. P. B.

REFERENCES.

803. *Mechanical Determination of Co-ordinates.* **N. Wesselovsky.** (Zeitschr. Instrumentenk., Beib. 6. p. 58, March 15, 1910.)—A short paper giving the theory of a proposed instrument for determining the co-ordinates of points in diagrams. A. W.

804. *Automatic Circular Dividing Engine.* **W. R. Stamper** and **E. R. Hall.** (Phys. Rev. 30. pp. 492-505, April, 1910.)—Illustrated description of the apparatus and of the method of calibration employed.

805. *Accelerated Velocity of Jupiter's Red-spot Hollow.* **S. Bolton.** (Nature, 83. p. 70, March 17, 1910.)—From the estimated positions on Oct. 25, 1909, and Feb. 25, 1910, the rotation period is found to be 9h. 55m. 37·9s., which is 2·7 sec. shorter than the adopted period. The approx. date when the present accelerated velocity first commenced was about May 2, 1909. C. P. B.

806. *Halley's Comet.* **K. Birkeland.** (Nature, 83. pp. 217-218, April 21, 1910.)—Calls upon astronomers to observe the curvature of the tail of Halley's comet when the latter is nearest Venus (May 2) and the earth (May 19). If Venus is magnetised as strongly as the earth, and the tail consists of electrified matter, it will be drawn in towards the planet. E. E. F.

807. *Intrinsic Brightness of Stars.* **C. Nordmann.** (Comptes Rendus, 150. pp. 669-672, March 14, 1910.)—As an extension of the application of Planck's law an attempt is made to determine the intrinsic brightness of certain stars by estimating the wave-length of the max. brightness of their spectra. A table of the results is given, showing that the order of effective brilliancy is in agreement with that of temperature gradation. [*Erratum*, p. 894, April 4, 1910.] C. P. B.

LIGHT.

808. *Diffraction Figures produced by Heliometer.* **P. F. Everitt.** (Roy. Soc., Proc. Ser. A. 83. pp. 302–323, March 2, 1910.)—The investigation was undertaken to determine the influence of the diffraction-figure spreading on the measurement of separation of two small artificial stars, for the recording of personal equation. The analysis was carried out by series expansion and by mechanical integration. The results are presented both in tabular form and as diagrams showing the contours of equal light-intensities. A photograph of the actual diffraction system is also reproduced. From these we see that the diffraction image is symmetrical about two perpendicular axes. There is a central approximately oval spot, which is a little less than twice as long as it is broad. This is divided along its major axis by a long bright ray, which fades away as it recedes from the centre. Around the spot and following its outline are other maxima gradually decreasing in intensity. C. P. B.

809. *Magnetic and Electric Birefraction of Aromatic Liquids: Theory of Molecular Orientation.* **A. Cotton** and **H. Mouton.** (Comptes Rendus, 150. pp. 774–777, March 21, 1910.)—The fact that the magnetic and electric birefraction of nitrobenzene vary in the same way with the wave-length [Abstract No. 1806 (1908)] has been confirmed by McComb and Skinner [Abstract No. 54 (1910)], who have extended the rule to a series of eight other liquids. The authors now find that the thermal variation of the electric birefraction of nitrobenzene is of the same sense and order of magnitude as, but more rapid than, that of the magnetic birefraction. The general course of these two phenomena, as well as the difference between them, can be explained by the hypothesis which regards the cause of these birefractions as consisting of an incomplete orientation of the molecules by the fields in which they are placed. Unlike the magnetic permeability, the dielectric constant of the liquid differs considerably from unity, and varies very appreciably with the temperature, and if the values of the electric birefraction are divided by the values of the dielectric constant relative to the same temperatures, numbers are obtained which are sensibly proportional to the magnetic birefractions. Orientation of a diamagnetic molecule may be imagined by supposing that the planes of the orbits of the different electrons have not all the possible orientations in the molecule, but that their assemblage possesses a characteristic anisotropism. Such a hypothesis affords also an explanation of various other phenomena.
T. H. P.

810. *Emission of Light and its Excitation.* **P. Lenard.** (Ann. d. Physik, 31. 4. pp. 641–685, March 15, 1910.)—In addition to the momentary and slow processes (*m*- and *d*-processes) of excitation already described [Abstracts Nos. 726 (1905)], 2048 (1907)], the existence of a third process (*u*-process), observed principally in the ultra-violet and of medium duration, has now been established. Curves are given showing, for each phosphore, the wave-lengths of the exciting light as abscissæ, and the intensities of the phosphorescent light as ordinates. The curves for the *m*- and *d*-excitations are quite dissimilar, the first possessing mostly one maximum and the second several nearly equidistant maxima. The wave-lengths of the exciting light corresponding with the maxima are

closely related to the dielectric constants for the different phosphores. The whole of the results obtained with different phosphores consisting of an alkaline earth sulphide and heavy metal, and also with zinc sulphide, render it probable that the illumination of the phosphore and emission of spectral lines by the metallic vapour are processes of the same kind in the atoms of the metal. The excitation of the phosphore consists in the separation of the "light-electric" electrons from the atoms of the metal. Illumination occurs on return of the electrons to the atoms, the so-called emission electrons thus being brought into a state of vibration. This view of phosphorescence and fluorescence leads to an explanation of Stokes' rule. T. H. P.

811. *Photometric Measurements of Coloured Bunsen Flames.* **E. Beckmann and P. Waentig.** (Zeitschr. Phys. Chem. 68. 4. pp. 385–489, Dec. 14, 1909.)—A quantitative measurement of the intensity of the colouration given by the salts of the alkali and alkaline earth metals. Different atomisers were used, and a new one was devised in which the quantity of salt supplied to the flame could be carefully regulated. The influence of various anions was observed, and also that of various indifferent salts. A section is also added dealing with the electrical conductivity of the flames, the colours of which were photometrically determined. E. C. C. B.

812. *Luminous Efficiency of the Firefly.* **H. E. Ives and W. W. Coblentz.** (Bureau of Standards, Bull. 6. pp. 321–336, Feb., 1910.)—A careful investigation is made of the light emitted by the firefly. The spectrum of "Photunis Pyralis" has been photographed on plates sensitive to the whole visible spectrum. The spectrophotometric curve of the firefly is compared with that of a carbon glow-lamp. The distribution of radiant energy in the carbon glow-lamp has been determined, and hence the distribution of the radiant energy of the firefly has been found. The light is found to consist of an unsymmetrical structureless band in the yellow-green of the spectrum, with a maximum at 0·57 μ, and a range extending from 0·51 μ to 0·67 μ. The luminous efficiency is computed to be 96·5 per cent. This compares with 0·4 per cent. for the carbon glow-lamp, and 4 per cent. for the most efficient artificial illuminant. This value is obtained on the assumption that there is no infra-red radiation other than that due to the natural body heat. There are reasons for believing that the light emitted is due to a physiological chemical reaction, not necessarily accompanied by heat waves of low frequency such as occur in a purely thermal (low-temperature) radiation. But even if heat waves of low frequency are generated they could not pass through the chitinous layer, which probably cannot transmit waves of lengths greater than 1·5 μ. It is to be noted that it is the radiant efficiency only which has been found. Whether the processes of physiological chemistry which are probably involved in this light-production are equally efficient is an entirely different question. [See also Abstract No. 60 (1910).] A. R.

813. *Method of Testing Visual Acuity.* **H. E. Ives.** (Electrical World, 55. pp. 939–940, April 14, 1910.)—The author points out that most of the devices and charts employed by observers in the past for the determination of visual acuity are open to objection on some ground. The ideal conditions to be met by such a device are: (1) That the detail inspected should be continuously variable in size; and (2) that the flux of light entering the eye, the distance of the object, and the observer's visual accommodation should remain constant. The author describes a method of securing the required conditions

which involves the superposition, one over the other, of two finely ruled gratings. As the inclination of the lines on the gratings is altered, the observer sees alternate dark and bright bands, the width of which is determined by their relative position. In using the apparatus the angle of inclination is adjusted until the bands are just indistinguishable; the corresponding angle is then noted and regarded as an index of visual acuity. The author presents some microphotographs explaining the exact action of the crossed gratings. J. S. D.

814. *Spectrum of a Carbon Compound in the Region of extremely Short Wave-lengths.* **T. Lyman.** (Amer. Acad., Proc. 45. No. 10. pp. 315–322, March, 1910.)—Two spectra only can be easily obtained in the extremely short wave-length region, those of hydrogen and of some carbon compound. This carbon compound the author believes with Schumann to be CO. The wave-lengths of the banded spectrum of this compound have now been measured between the limits $\lambda = 2068$ and $\lambda = 1335$, and it has been found that Deslandres' first two laws are obeyed within reasonable approximation. E. C. C. B.

REFERENCES.

815. *Luminosity and Temperature.* **P. G. Nutting.** (Bureau of Standards, Bull. 6. pp. 337–346, Feb., 1910.)—The paper is of a mathematical nature. The author seeks to obtain a relation connecting the luminosity of a black body and its temperature by combining the well-known relations for radiation with a "visibility function." The ground covered is very similar to that previously entered upon [see Abstract No. 1367 (1909)]. J. S. D.

816. *Dispersion by Metals in the Visible Spectrum.* **C. Zakrzewski.** (Acad. Sci. Cracovie, Bull. 3a. pp. 77–89, March, 1910.)—An elliptic analyser described by the author [Abstract No. 700 (1908)] was employed in measuring the elements of the light reflected from a metallic mirror. The theory of the method is given, and the values of the refraction indices and extinction coefficients for a plate of pure Pt as determined by means of the method are tabulated. The extinction coefficients are uniformly higher than those found by Hagen and Rubens by direct measurement of the absorption. G. E. A.

817. *The Petzval Condition.* **A. Gullstrand.** (Zeitschr. Instrumentenk. 30. pp. 97–105, April, 1910.)—A mathematical discussion with the object of delimiting the sphere of application of the Petzval condition, experience having shown that the fulfilment of the condition sometimes has an astonishingly large effect, but in others is of extremely little use. G. E. A.

818. *Interference produced by the Black Rays of the Solar Spectrum.* **C. Fabry** and **H. Buisson.** (Journ. de Physique, 9. pp. 197–205, March, 1910.)—A description of the phenomena observed with an interferometer and an auxiliary spectroscope when the source contains reversed lines as in the case of the solar spectrum. E. C. C. B.

819. *Dispersion and Absorption by Metals for the Visible and Ultra-violet Spectrum.* **W. Meier.** (Ann. d. Physik, 31. 5. pp. 1017–1049, April 5, 1910. Extract of Dissertation, Göttingen.)—Measurements of the dispersion and absorption by Au, Ni, Fe, Pt, Bi, Zn, Hg, also for alloys of Cu and Ag, Wood's alloy, and Se and I. To these are added calculations of the constants of the free and bound electrons in each case. E. C. C. B.

HEAT.

820. *Spectral Pyrometer.* **F. Henning.** (Zeitschr. Instrumentenk. **30.** pp. 61–75, March, 1910. Communication from the Physikal.-Techn. Reichsanstalt.)—Holborn and Kurlbaum in 1901 devised an optical pyrometer which was very simple in construction [see Abstracts Nos. 2122 (1901), 1196 (1908)]. The present paper describes a modification of the above in which use is made of a constant-deviation spectroscope. The pyrometer tube (which is similar to Holborn and Kurlbaum's form) is placed in line with the collimator and close to the slit of the spectroscope, and its objective is arranged to give an image of the glowing body in the place where the lamp is. The other lenses of the apparatus are so arranged that an image of both lamp filament and glowing body is seen on looking through the eyepiece of the spectroscope. By rotating the prism of the spectroscope any colour required can be obtained; the wave-length of the light used is thus known from a calibration of the micrometer screw which is used to turn the prism. For the standardisation of the glow-lamp an electrically heated black body like that of Lummer and Kurlbaum [Abstract No. 1871 (1901)] was used. Twelve different lamps were experimented with, some having carbon filaments and others metal filaments. The research showed that for a metal filament the value $\theta = 1/T - 1/T_0$, where T and T_0 are the absolute black temperatures corresponding to wave-lengths λ and λ_0, does not vary with the true temperature. Measurements of the hitherto unknown reflecting power of Rh, Ta, and Ir were also made. It was also found that the absorbing power of Pt and also of Ir is independent of the temperature. A measure of the colour of an incandescent metal is given by the temperature $\mathfrak{T}$ of a black body which possesses, for two wave-lengths as far apart as possible from one another, the same brightness-ratio as the incandescent metal. The magnitude $\mathfrak{T}$, which is to be found from the black temperature and the value of θ, is at the same time an upper limit of the true temperature of the metal, and from it can be calculated a lower limit for the absorbing power of the metal. For tables of results see original paper. A. W.

821. *Specific Heats at Low Temperatures.* I. **W. Nernst, F. Koref, and F. A. Lindemann.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 12. pp. 247–261, 1910.)—The authors describe a new copper calorimeter, consisting of a block of copper about 400 gm. in weight, provided with a deep, concentric cavity for the reception of the substance the specific heat of which is to be examined. Arranged circularly round this aperture are small openings containing constantan-iron thermo-elements, the alternate junctions of which are embedded in an upper copper block forming a cover to the vacuum-vessel surrounding the calorimeter. The cavities in the calorimeter and also the glass tubes containing the thermo-junctions are filled with Wood's metal. The calorimeter is placed in a thin-walled Dewar's vessel, the space between the copper and the glass being occupied by Wood's metal. The substance to be investigated is placed in a small silver vessel, and its temperature is measured thermo-electrically. The e.m.f. showing the change in temperature of the calorimeter is measured by means of a millivoltmeter, a change of 1° corresponding with 20 divisions of the scale, which can be read to 0·1 of a division. The instrument is repeatedly calibrated between the measurements by means of a substance (lead) of known specific heat, the rise of temperature employed being 2–8°. The thermo-elements are calibrated against a Beckmann thermometer. With the calorimeter at 0° and the substance at 20–48°, the following specific heats were obtained (Lindemann): Copper, 0·09155; zinc, 0·0949; rhombic sulphur, 0·1708; hydrated (0·2688) and anhydrous potassium ferrocyanide, 0·2142; hydrated (0·3742) and anhydrous oxalic acid, 0·2785; potassium iodide, 0·0766; calcium carbonate, 0·2027; calcium oxide, 0·1821; disodium hydrogen phosphate $+12H_2O$(0·3728) and $+7H_2O$(0·3280). Also, the mean specific heats of a number of substances were measured over a moderately wide temperature-interval, the extreme temperatures employed being that of liquid air and about +80° (Koref). The detailed results are given in the form of a table. With benzophenone and betol the specific heat diminishes considerably as the temperature is lowered.

T. H. P.

822. *Specific Heats at Low Temperatures.* II. **W. Nernst.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 12. pp. 262–282, 1910.)—The method described in the preceding Abstract giving only the mean specific heat over a considerable temperature-interval, the author employs Eucken's apparatus [Abstract No. 1714 (1909)] to measure the true specific heats of a number of substances at temperatures down to below −200°. The substance to be examined itself serves as calorimeter, and is suspended in a highly exhausted vessel, and surrounded by a long Pt-wire, which serves both as an electrical source of heat and as resistance thermometer. If a metal is to be examined it is used in the form of a thick-walled hollow cylinder, into which fits a massive piece of the same material; the Pt-wire, isolated by paraffined paper, passes between these two. Bad conductors are placed in a silver vessel containing a silver tube, round which the insulated Pt-wire is wound. The specific heats of a number of the substances mentioned in the preceding Abstract were measured, the general result being that the specific heat diminishes with increasing rapidity as the temperature falls. For ice the molecular heat $= 8{\cdot}47 + 0{\cdot}0276t - 14{\cdot}0/t$, which agrees well with Koref's observations [see preceding Abstract], but is not in good agreement with the values obtained by previous investigators. For temperatures down to −40° the atomic heat of lead is expressed by the formula $6{\cdot}31 + 0{\cdot}2t/100$, and from −80° to −210° by $6{\cdot}31 + 0{\cdot}2t/100 - 0{\cdot}55t^2/10^5$. At very low temperatures specific heats approach zero or, at any rate, become very small; for instance, at −210° silver has the value 0·0848, glass 0·047, paraffin 0·12. This approximate or complete vanishing of the specific heat is in perfect agreement with the thermodynamic relationship obtained by the author [Abstract No. 580 (1907)].

T. H. P.

823. *Determination of Specific Heats.* **A. Magnus.** (Ann. d. Physik, 31. 3. pp. 597–608, March 1, 1910.)—The method adopted by the author for measuring specific heats is as follows: Two similar large (60-litre) vessels containing equal amounts of water are placed side by side, and separated by a plate of cork in a well-insulated chamber. After temperature-equilibrium had set in, the small difference of temperature between these two vessels was measured. After introducing the heated substance into one of the vessels the change of the temperature-difference with time is followed, the results being extrapolated backwards. The temperature-difference is measured by means of a thermopile of 100 constantan-copper elements and a sensitive

galvanometer. The details of the method are described in the paper. The results obtained are as follows :—

Substance.	Temperature Range.	Specific Heat.	Mean Molecular Heat.
Pb....................	18–100°	0·03095–0·03096	6·409 ± 0·001
,, ...	16–256	0·03182–0·03198	6·606 ± 0·009
Soft glass..........	17–100	0·2002–0·2006	—
,, ...	17–218	0·2172–0·2178	—
,, ...	17–329	0·2299–0·2303	—
Al	16–100	0·2119–0·2125	5·750 ± 0·006
,, ...	16–304	0·2249–0·2250	6·097 ± 0·001
,, ...	17–547	0·2388–0·2390	6·475 ± 0·008
Ag....................	17–507	0·05981–0·05989	6·460 ± 0·003
,, ...	16–614	0·06145–0·06163	6·641 ± 0·009
Cu....................	15–238	0·09510	6·048
,, ...	15–338	0·09575	6·090

The specific and molecular heats of the compounds $PbCl_2$, $AgCl_2$, PbI_2, HgCl, AgI are also given. A theoretical discussion of these results is to appear later. T. H. P.

824. *Specific Heat and Heat of Solidification of Pig-iron.* **W. Schmidt.** (Metallurgie, 7. pp. 164–168, March 22, 1910.)—Swedish pig-iron was fused in a carbon crucible and introduced into an ice calorimeter, the temperature being measured by means of a thermo-couple. Experiments were carried out at 1375°, 1275°, 1175°, and 1130° C.; in the latter case the metal was introduced into the calorimeter immediately after solidification. Analysis of the samples showed the carbon-content to be about 4·3 per cent., which corresponds closely to the composition of the eutectic. The results show that the specific heat of iron between 1175° and 1275° is 0·3136, and between 1275° and 1375° C. is 0·3216. Assuming that at 1130° C. the specific heat of iron is 0·31, the heat of solidification of white pig-iron of the eutectic composition is 59 cals. per gm. F. C. A. H. L.

825. *Specific Heats of Calcium Chloride Solutions between* −35° *and* +20°. **H. C. Dickinson, E. F. Mueller,** and **E. B. George.** (Bureau of Standards, Bull. 6. pp. 379–408, Feb., 1910.)—The authors have adapted (1) the continuous-flow calorimeter, and (2) the vacuum-jacketed (Dewar flask) calorimeter to the determination of specific heats of liquids over a temperature-range of a few degrees in the interval between −35° and +20°, measurement of temperature being made by Pt-resistance thermometers, and heat being supplied electrically and measured accurately by the potentiometer method. By the use of the flow calorimeter an accurate determination of the water-equivalent is avoided, so that it is adapted to the fundamental determination of specific heats of liquids, especially that of water, in terms of the electrical units; further, there is no loss by radiation. With the vacuum-calorimeter, on the other hand, a radiation constant and a water-equivalent must be determined, the latter being difficult to determine accurately. When, however, the vacuum-calorimeter is used to determine the heat capacity of a substance compared with that of water, the error in determination of the water-equivalent becomes of very small importance; in the present case the total correction for water-equivalent and radiation was reduced to less than 4 per cent. The flow calorimeter is subject to a large error in the measurement of the temperature-difference, particularly when the liquid has high viscosity, on account of the necessity of measuring the temperature at certain points in the flowing stream; if resort is had to mixing, the difficulty of obtaining constant flow is increased. The flow calorimeter, when used for determining the specific heat of a single sample of calcium chloride solution, gave results showing individual variations as large as 1 per cent., and final results, which are probably accurate, to 0·2-0·3 per cent. By means of the Dewar flask calorimeter, which gives results agreeing by less than 0·2 per cent., the following values were obtained for the specific heats of pure calcium chloride solutions:—

Temperatures.	Densities at 20°/4°.			
	1·07.	1·14.	1·20.	1·26.
—25°	—	—	—	0·648
—20	—	—	0·695	0·651
—15	—	0·764	0·700	0·654
—10	—	0·768	0·705	0·657
— 5	0·873	0·772	0·709	0·660
0	0·877	0·775	0·712	0·663
5	0·880	0·778	0·715	0·667
10	0·882	0·781	0·719	0·670
15	0·884	0·784	0·722	0·673
20	0·887	0·787	0·725	0·676

The following empirical formula gives a relation between density and specific heat at 0°, satisfying the above numbers to within 0·1 per cent.: $D = 2{\cdot}8821 - 3{\cdot}6272\sigma + 1{\cdot}7794\sigma^2$, where D is the density and σ the specific heat. The following freezing-points of solutions of pure calcium chloride of various densities were determined: 1·12, —9°; 1·14, —13°; 1·16, —16°; 1·18, —20°; 1·20, —24°; 1·22, —29°; 1·24, —34°; 1·26, —40°. T. H. P.

826. *Thermal Properties of Steam.* **H. N. Davis.** (Amer. Acad., Proc. 45. No. 9. pp. 267-311, March, 1910.)—Previous determinations of the total heat of steam (H), and of the latent heat of evaporation (L), are summarised, and the author introduces his formula for H, and the reasoning connected with it already published [see Abstract No. 8B (1909)] in order to show in detail the working out of values of H derived from the results of experimenters such as Henning and Joly. In section 4 of the paper various computations of the specific heat of superheated steam are discussed and revised in the light of the author's new value of H and of the Joule-Thomson coefficient. This is held to justify the author's choice of Knoblauch's values of C_p, as the foundation of his determination of H. It is shown that Clausius' specific heat of saturated steam passes its maximum without becoming zero or positive, so that the temperature-entropy diagram for steam must be essentially simpler than that for ether or chloroform. Thiesen's formula for L with re-computed constants is shown to represent satisfactorily all the reliable values of L, including the author's. This formula is made the basis of a determination of the critical density of water by the Cailletet and Mathias' method. The result is $v_c = 3{\cdot}04$ cm.³/gm. The specific volumes of

water and of saturated steam at other high temperatures have been computed and embodied in Marks and Davis's steam tables, running up to the critical temperature [see Abstract No. 909B (1909)]. **F. J. R.**

827. *Measurement of the "True" and "Black Body" Temperatures of Metals.* **M. v. Pirani.** (Deutsch. Phys. Gesell., Verh. 12. 7. pp. 301–348, April 15, 1910.)—In all investigations into the temperature of incandescent bodies a distinction must be drawn between the true and the "black body" temperatures, and in examining the difference in these quantities it is convenient to adopt some method of investigation which is independent of the nature of the radiating surface. The author selects the property of specific resistance for this purpose, and describes a series of researches serving to establish a connection between the temperature and specific resistance of Pt, and tantalum and tungsten filaments. In view of the uncertainty as to the temperature of incandescence of metallic filaments the selection of these last two materials is of interest. The first portion of the paper is devoted to a description of methods and apparatus. Two distinct systems of heating the metals were adopted, namely, by external means and by means of the current measured. From the results so obtained the author proceeds to demonstrate an apparent difference between the true and black-body temperatures, this difference becoming more marked as the temperature is increased. He also discusses the mathematical connection between temperature and resistance, and temperature and emissivity, and develops two empirical formulæ by the aid of which results can be exterpolated. He gives the normal temperature of incandescence of tantalum and tungsten as about 2000° C., the specific consumption in the two cases being 1·2–1·8 and 1·1 watts per hefner candle respectively. The former result is in good agreement with that of Waidner and Burgess, the latter somewhat below the observation of these investigators. The author also attempts to form an idea as to the true melting-point of tungsten and tantalum, which he states to be 3350° and 3100° on the Holborn scale, or 3250 and 3000 on the older system of reckoning. **J. S. D.**

828. *Thermodynamics of Black Radiation.* **P. Saurel.** (Phys. Rev. 30. pp. 350–355, March, 1910.)—Planck has recently [see Abstract No. 1480 (1907)] obtained formulæ expressing the energy, the entropy, the electromagnetic momentum, and the pressure of a moving hollow space, which is the seat of black radiation, in terms of its volume, temperature, and velocity. The author here shows that the same formulæ may be very simply derived from general thermodynamic principles, combined with the expression, as a result of electromagnetic theory, of the radiation pressure as equal to one-third of the specific energy, together with an electromagnetic theorem due to Planck. **G. W. DE T.**

829. *Wien's Law.* **P. Saurel.** (Phys. Rev. 30. pp. 356–358, March, 1910.)—A similar method to that employed in the preceding Abstract is here used to establish Wien's displacement law. The radiation in the hollow space is assumed to contain only waves whose frequencies lie between zero and a fixed upper limit, and, further, that the energy of the system is a homogeneous function of the first degree of the entropy, the volume, and the radiation. The law is then obtained by aid of the expression of the radiation pressure as equal to one-third of the specific energy. **G. W. DE T.**

830. *Theory of Radiation.* **M. Planck.** (Ann. d. Physik, 31. 4. pp. 758–768, March 15, 1910.)—The author considers Jeans's radiation theory [see Abstract No. 1578 (1909)] as the most complete and satisfactory one yet presented, but maintains that it is in conflict with experiment in expressing the intensity of radiation from a black body in terms of a single universal constant, whereas the author maintains that it should contain at least two. Jeans's formula may be considered as the limiting value for the case in which the second constant vanishes. This second constant, which the author denotes by *h*, may be regarded as providing for Larmor's "elements of disturbance" [see Abstract No. 704 (1910)]. Einstein [see Abstract No. 909 (1909)] and Stark [see Abstract No. 250 (1910)] argue, from similar considerations, that the electromagnetic wave theory of light should be abandoned in favour of a corpuscular theory. The author considers that the difficulty may be solved without any such radical changes in physical theory. His solution is to replace the single differential equation determining the motion of a simple oscillator, at any rate at, and shortly after, excitation, by a finite series of equations, each holding good only for a definite instant, the number and character of the series varying with the nature of the excitation. This would make the Hamilton equations inapplicable to the vibrations of an oscillator, carrying the further consequence that the equipartition law would not be generally applicable to radiation. The relation between the mean energy of an oscillator and the mean intensity of radiation for corresponding periodicity would remain the same as if the energy of the oscillator were supposed, as in the ordinary theory, to vary continuously. G. W. DE T.

REFERENCES.

831. *Adiabatic Calorimeter for Use with the Calorimetric Bomb.* **F. G. Benedict** and **H. L. Higgins.** (Amer. Chem. Soc., Journ. 32. pp. 461–467, April, 1910.)—Description with illustration; method of making a combustion; calculation of results.

832. *Electrically Controlled Thermostat for Determination of Electrolytic Conductivity of Highly Conducting Solutions.* **J. Gibson** and **G. E. Gibson.** (Roy. Soc. Edinburgh, Proc. 30. pp. 254–264, 1909–1910.)

833. *Optical Measurements of the Temperature of Polished Substances.* **H. v. Wartenberg.** (Deutsch. Phys. Gesell., Verh. 12. 3. pp. 121–127, Feb. 15, 1910.)—Using Holborn and Henning's formula connecting the true and apparent temperatures of bright bodies when their temperature is measured with an optical pyrometer, the author has extended the measurements up to 2,900° C. He utilised a tungsten tube electrically heated. [See Abstract No. 1287 (1905).] E. C. C. B.

834. *Loschmidt's Number from Argon.* **W. Hillers.** (Phys. Zeitschr. 11. pp. 133–134, Feb. 15, 1910.)—The author, by reference to the theoretical gas data for argon, confirms the value found by M. Planck for Loschmidt's number N. The paper is written as a remark on the work of H. Sirk [Abstract No. 1069 (1909)]. E. H. B.

SOUND.

835. *Apparatus for Sound Interference.* **E. Waetzmann.** (Ann. d. Physik, 31. 4. pp. 837–840, March 15, 1910.)—By means of a screwed T-piece, three cast-iron pipes are arranged in the form of a large T. Calling the upper stroke of the T the main pipe and the down stroke the branch pipe, the lengths were 8½ m. and 1½ m. respectively, the diameters being 5 cm. inside. The whole being placed horizontally, the upper sides of main and branch pipes are provided with holes 1½ mm. diam. and 1½ cm. apart. One part of the main pipe is 1½ m. long, and is closed at the end by a rubber membrane, in front of which is placed some source of sound such as a fife. The branch pipe and the other part of the main pipe are fitted with sliding stoppers adjusted by rods graduated in cm. Gas is supplied to the interior, and the jets issuing from the holes along the upper sides are lit and adjusted to a height of flame of about 1 cm. *First*, let the stopper in the branch pipe be set right in as far as the bore of the main pipe. We have then the main pipe alone in use, and the apparatus reduces to a Rubens sound tube. On producing the sound near the rubber-covered end, the flames indicate the nodes and antinodes along the main pipe. *Second*, let the stopper in the branch pipe be withdrawn a *quarter wave-length* of the sound in use. Then we have in the branch pipe and between it and the rubber stopper the indication of nodes and antinodes as before; but in the remainder of the main pipe the pressure is uniform and constant and the flames all burn alike. A shift of the stopper in the main pipe has no effect in this state of things, which may be repeated by withdrawing the stopper in the branch pipe to any *odd number* of quarter wave-lengths from the main pipe. Other positions are also of interest. [See Abstract No. 1611 (1905).] E. H. B.

836. *Extinction of Tone in Iron.* **Robin.** (Comptes Rendus, 150. pp. 780–781, March 21, 1910.)—Bars of iron suitably supported give, on being struck, a principal note, the intensity of which is found to be a peculiar function of the temperature. With increase of temperature the intensity diminishes until, when 100° is reached, the note can no longer be heard. As the temperature rises from 150° to a dull red heat, the sound returns, attains a maximum, and again falls off to zero intensity. The "extinction interval" depends on the carbon-content of the iron or steel. It is 100°–150° for pure iron, 95°–145° for 0·2 per cent. carbon steel, and 85°–120° for 0·45 per cent. carbon steel. The phenomenon was not observed in a steel containing 1·8 per cent. carbon. A. D. R.

837. *Silent Chamber at Utrecht.* **H. Zwaardemaker.** (Konink. Akad. Wetensch. Amsterdam, Proc. 12. pp. 706–710, April 28, 1910.)—This "camera silenta" has now been in use since 1904, and was described by S. J. Franz [see Abstract No. 827 (1908)]. Its constructor now gives the result of experience with it up to date. To prevent disappointment such a chamber should fulfil three conditions: (1) The inner surface of the walls should be covered with a material which does not reverberate. (2) The isolation must be effected by a double wall, with interstices of air of such a trifling thickness that resonance of audible tones is quite out of the question and no connection is left between the two walls other than a few narrow lead contacts. (3) The isolation of the outer wall of the building and of its bottom has to be as complete as possible; the first isolation should take place through a properly constructed secondary apartment. The methods of fulfilling the first two conditions have been described in the former Abstract. The third condition requires the exclusive use of lead contacts. The bottom must be arranged with special care. At Utrecht faults have been discovered in this respect, which could only be partially remedied by the subsequent addition of an extra covering. If a choice has to be made of a position underground or on a higher floor for such a sound-proof chamber, the author is decidedly in favour of the higher floor, for the conduction of sound in by the *bottom* is the defect most difficult to overcome, and this difficulty is reduced in the higher floor as compared with a basement. Among the ten researches carried on by the author in this chamber during the last six years, the following may be specially noticed: (1) Unless a perforation of the tympanum exists, the "sensation of stillness" may be observed as a kind of buzzing, in which, on a closer analysis, a soft rustling as of the wind in the tops of trees may be distinguished, accompanied by a high-pitched whistling ($\pm g^6$). Persons in whom this physiological ear-buzzing is indistinct perceive a feeling of oppression. (2) The spreading of the sound round a tuning-fork with the situation of the well-known interference-planes may be accurately traced, without making the mistakes that must necessarily arise in apartments with echoing walls. (3) The action of the winding mollusc-shells as to their resonance for buzzes may be proved directly. (4) The sound-extinguishing action of different means of isolation may be traced with perfect security. For reports by dropping steel balls on a steel plate and for tones by electrically touching purely tuned bells, in both cases the instrument is put in a small non-resonant space whose walls are covered with the material to be examined. The completest isolation for a given thickness of walls is got for *trichopièse*, then follows the peat-moss plate from Klazienaveen, then the corkstone.

E. H. B.

838. *Extinction of Sound in a Viscous Atmosphere by Small Cylinders and Spheres.* **C. J. T. Sewell.** (Roy. Soc., Phil. Trans. 210. pp. 239–270, May 4, 1910.)—The theory of the incidence of waves of sound in a non-viscous air upon small obstacles of cylindrical or spherical form is well known from the treatment of it by Rayleigh (Theory of Sound) and by H. Lamb (Treatise on Hydrodynamics). The corresponding problems for a viscous air are treated in the present paper. The problems have some practical interest. It has been asserted that the suspension of a large number of parallel wires in a hall or lecture-room will improve the acoustic properties of the room. According to the ordinary theory of a non-viscous air, the effect of any such arrangement of wires would be inappreciable. From the results of this investigation also, the author concludes that the viscosity of the air is not sufficient to account for the alleged phenomenon. The results in the case of spherical obstacles are of yet greater interest, since they are applicable to the consideration of the effect of foggy weather upon the propagation and audibility of sound. If the diam. of the drops of water in a dense fog is assumed to be 0·02 mm., there is no appreciable alteration in the audibility of sound on this theory. But in the case of drops of water whose diam. is 0·002 mm., it at first appeared, from the formulæ developed, that the fog would be then prejudicial to the audibility. However, on treating these very small drops as free instead of fixed, it was found that they also fail to appreciably lessen the audibility of sounds. Thus for both these cases the theory is in agreement with Tyndall's experimental researches on the subject. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

839. *Convection Currents. Measurement of* v. **A. Guillet.** (Annal. Chim. Phys. 20. pp. 181–188, May, 1910.)—A turning disc is generally employed to study the magnetic field due to convection. In this case the calculation is complicated and the experimental work laborious. A turning cylinder is much more convenient. If a cylinder of length $2l$ and radius R carries a charge of density σ, and turns round its axis with an angular velocity ω, the intensity ϕ of the field which it produces at its centre is given by—

$$\phi = 4\pi\omega R\sigma/[1 + (R/l)^2]^{\frac{1}{2}}.$$

This resultant is obtained by substituting for the quantity ni in the classical formula which gives the field in the interior of an inductive coil, the corresponding quantity $\omega R\sigma$ which measures the charge that passes in unit of time before a fixed index of unit length which is parallel to the generating lines of the cylinder. It suffices, therefore, to wind a single-layer coil on an external concentric cylinder to enable us to compensate the field of convection by the field of conduction. If I be the electromagnetic value of the required current, N the number of turns, and $E \times 10^8$ the potential of the charge in c.g.s. electromagnetic units, we obtain—

$$\omega RE \times 10^8/v^2 4\pi R \log (R'/R) = NI/2l$$

and thus—

$$v^2 = 2\omega RE \times 10^8 l/NI4\pi R \log (R'/R).$$

In practice I is of the order 10^{-5} or 10^{-6} amp. The author also investigates formulæ for alternating convection currents. A. R.

DISCHARGE AND OSCILLATIONS.

840. *Emission of Photoelectric Kathode Rays.* **J. Robinson.** (Ann. d. Physik, 31. 4. 769–822, March 15, 1910. Extract of Dissertation, Göttingen, 1909.)—Investigates the manner in which electrons escape from a plane electrode, and the absorption of kathode rays of various velocities by different gases. The author tests Riecke's formula for the total charge of the kathode rays leaving a flat electrode of radius a and caught by a Faraday cage with an opening of radius b placed at a distance D. If N_0 is the number of electrons leaving unit of surface, this total charge is—

$$\pi N_0 \frac{a^2b^2}{D^2}\left\{1 - \frac{3}{4}\frac{a^2+b^2}{D^2} + \frac{5}{8}\frac{a^4+3a^2b^2+b^4}{D^4}\right\}$$

neglecting higher powers. When an electric field is superposed upon the paths these become parabolas, and the paths are concentrated in a ratio called the "concentration factor." Riecke's formula only appears to hold good when D is kept constant and only the potential is varied. This is due to the fact that the concentration factor varies but little with the angle of emission of photoelectric kathode rays, which can be followed up to 75°. The behaviour of kathode rays in a magnetic field shows that the distance between two nodes agrees well with Riecke's theory. But the quantitative relations of the charges received by the Faraday cage can only be explained if the rays are emitted in a manner different from that assumed by Riecke, and notably if the limiting angle of emission is much larger. Measurements of the absorption of kathode rays were made in nitrogen, oxygen, and CO, as well as hydrogen. In all gases except hydrogen Lenard's theory was confirmed, the limiting absorption for small speeds substantially agreeing with the total molecular areas in 1 c.cm. of the gas at the same pressure. New values of the molecular diameters were thus determined, and found to be the following: H_2 2·37, O 2·59, N 3·5, CO 3·5, Ar 3·14, CO_2 3·44 (all $\times 10^{-8}$ cm.). Planck's values for Avogadro's numbers were assumed. E. E. F

841. *Photo-electricity of Alkali Metals.* **F. K. Richtmyer.** (Phys. Rev. 30. pp. 385–393, and pp. 394–396, March, 1910. Papers read before the Amer. Physical Soc.)—Determines quantitatively the relation between wave-length and photoelectric current for sodium, which has a maximum in the visible spectrum. The Pt wire leading to the sensitive surface was charged to such a negative potential as to reduce the leakage current through the walls of the cell to zero, thus making the photoelectric surface at zero potential with respect to the receiving Pt wire. Under those conditions the rate of deflection of the electrometer as measured by a chronograph was proportional to the photoelectric current. A Nernst glower, and subsequently an acetylene flame, were used as sources. The spectrum curve of the latter was reduced to portions of equal energy by means of Nichols and Merritt's determinations. Some of the values of the photoelectric currents for a given incident energy in various parts of the spectrum of acetylene light are given in the following table:—

$\lambda \times 10^4$.	Current.	$\lambda \times 10^4$.	Current.
0·685	0·0081	0·499	6·77
0·635	0·0355	0·488	8·49
0·596	0·298	0·462	10·00 (max.)
0·565	1·095	0·440	8·52
0·540	2·58	0·420	4·64
0·518	4·48	—	—

The significance of the curve is obscure, since $\lambda = 0{\cdot}46\,\mu$ does not seem to bear any unique relation to any of the known properties of sodium. It suggests some kind of resonance, the expulsion of the electron being due to the selective absorption of light. A rough calculation shows that the amount of light absorbed by the sodium is quite capable of imparting the observed velocities to the expelled electrons. In the second paper, the author gives some practical applications of the photoelectric sensitiveness of sodium, which permits the detection of a very dim light. One is the study of the rate of decay of phosphorescence, and the other the measurement of the efficiency of a photographic shutter. The photoelectric cell measures the quantity of incident energy much as the electrolytic cell measures the quantity of electricity. E. E. F.

842. *Photoelectric Properties of Alkali Metals.* **R. Pohl and P. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 12. 5. pp. 215–228, March 15, and 12. 7. pp. 349–360, April 15, 1910.)—In the first paper the authors explain the disagreement between the results of Elster and Geitel and J. Braun on the one hand, and of Hallwachs on the other by showing that the maximum of photoelectric effect depends essentially upon the orientation of the light vector with respect to the surface of the metal. When the light falls perpendicularly upon the surface of a K-Na alloy, the photoelectric action increases steadily with decreasing wave-length, as in all other metals. When, however, the angle of incidence is not zero, there is a practically absolute maximum for a certain wave-length ($\lambda = 400\ \mu\mu$). The factor of proportionality between the light absorption and the photo-effect produced by the electric vector component of natural light oscillating in the plane of incidence is a function of the wave-length, and the maximum at $400\ \mu\mu$ indicates a resonance phenomenon. In the second paper, the authors endeavour to determine the relative importance of Na and K in the photoelectric properties of the alloy. They examined the amalgams of the two metals, and found to their surprise that they show no "critical wave-length." They therefore examined the pure metals in the solid state, having found that there is no essential change of optical properties on solidification. They then found that for the pure metals there are critical wave-lengths for which the photoelectric current shows a sudden increase due to the component of the elector vector oscillating normally to the metallic surface. The maxima of the critical regions are approximately at $\lambda = 480\ \mu\mu$ for Rb, $440\ \mu\mu$ for K, and $320\ \mu\mu$ for Na. In the case of a K-Na alloy with 69·4 per cent. K the maximum is at about $390\ \mu\mu$, and is too sharp to be due to a superposition of K and Na maxima. This, and the absence of a critical wave-length in the amalgams, indicate that we have to do with a resonance phenomenon connected with the molecular binding of the alkali atoms. E. E. F.

843. *On the Electricity of Rain and Snow.* **G. C. Simpson.** (Roy. Soc., Proc. Ser. A. 83. pp. 394–404, March 22, 1910.)—The experiments described in a previous paper [Abstract No. 1078 (1909)] have been continued during the monsoon of 1909. The apparatus was set up on a new site. A few minor modifications were made in it, chief among which was the fixing of a more powerful radium collector to the insulated rod used for recording electrical potential. The results for the season 1909 confirm those of 1908 in most particulars. The results for the two seasons may be summarised: (1) The electricity brought down by rain was sometimes positive and sometimes negative, but the total quantity of positive electricity was 3·2 times greater than the total quantity of negative electricity. (2) The period during which positively charged rain fell was 2·5 times longer than the period during which negative rain fell, but the excess was less marked the greater the charge on the rain. The ratio decreased from 2·8 for charges of less than 1 unit per cm.^{3} to 1·6 for charges above 3 units per cm.^{3}. (3) Treating charged rain as equivalent to a vertical current, the current densities were generally smaller than 4×10^{-15} amp./cm.^{2}, though on a few occasions greater current densities, both positive and negative, were recorded. (4) Negative currents occurred less frequently than positive currents, and the preponderance of positive currents increased with increasing current from 2·2 for currents under 50×10^{-15} to 6·9 for currents between 150 and 200×10^{-15} amp./cm.^{2}. (5) The charge per cm.^{3} of water was generally less than 6 e.s. units. (6) With all rates of rainfall, positively charged rain occurred more frequently than negatively charged rain, and the relative frequency of positive increased rapidly with increased rate of rainfall from 1·8 for rates less than 0·16 mm. in two minutes to 20 for rates of 1·7 mm. per 2 min. and over. (7) When rain was falling at a rate of less than 0·6 mm. in 2 min., the charge per cm.^{3} decreased as the intensity of rainfall increased. (8) For greater intensities of rainfall the positive charge per cm.^{3} was about 0·25 e.s. unit, and independent of the rate of rainfall, while the negative charge continued to decrease as the rate of rainfall increased. In 1908 there were no cases of negatively charged rain falling at a greater rate than 1 mm. in 2 min., but in 1909 there were 14 such occurrences. This fact is not looked upon as weakening the conclusions drawn in the previous paper regarding the origin of the electricity of thunderstorms. (9) During periods of rainfall the potential gradient was more often negative than positive, but there were no clear indications of a relationship between the sign of the charge on the rain and the sign of the potential gradient. (10) The data do not suggest that negative electricity occurs more frequently during any particular period of a storm than during any other.—It was also possible to obtain some information regarding the electricity brought down by snowfall. (1) More positive than negative electricity is brought down by snow in the proportion of about 8·6 to 1. (2) Positively charged snow falls more frequently than negatively charged. (3) The vertical currents during snow are on the average larger than during rainfall. (4) The charge per unit mass of precipitation is larger during snowfall than during rainfall. R. G. K. L.

844. *Secondary Kathode Rays.* **J. Herweg.** (Phys. Zeitschr. 11. pp. 170–171, March 1, 1910.)—Stark showed experimentally that the maximum of intensity of the Röntgen radiation sent out by a carbon antikathode placed at right angles to the path of the kathode rays lies behind the antikathode. In the phenomena at the antikathode γ-rays and Röntgen rays seem to behave similarly. When kathode rays fall on the front of a carbon antikathode, on their sudden stoppage a Röntgen radiation spreads out chiefly towards the back. These Röntgen rays develop, on their way through the antikathode, secondary rays which, according to Bragg, follow the direction of the Röntgen rays. The intensity maximum of this secondary kathode radiation must thus likewise lie behind the antikathode. This is confirmed by the observation of the author, who noticed that the portions of a Röntgen tube with a carbon antikathode which lie behind the antikathode become strongly blackened through disintegrated carbon, whilst the other portions show only slight blackening. Now, as disintegration and kathode radiation go hand-in-hand, it may be concluded that the blackening is due to the secondary kathode rays which are developed by the Röntgen rays and travel in the same direction as these. J. J. S.

845. *Neutral Doublets at Atmospheric Pressure.* **A. E. Garrett** and **J. J. Lonsdale.** (Nature, 83. pp. 218–219, April 21, 1910.)—Describes experiments indicating Righi's "magnetic rays" at ordinary pressures. Ionised gas is drawn through two insulated metal tubes; along the axis of each a thick insulated wire electrode is fixed. These wires can be connected in turn to a Dolezalek electrometer, and the current between tube and electrode measured. The ionised gas is produced by splashing mercury, or by heating lime or aluminium phosphate on a strip of Pt-foil. With a current blast, in one case, the current reached its saturation value on the first electrode with a voltage of 320, being then 180 in arbitrary units. Raising the voltage to 658 did not increase this by one division; the extreme readings at the intermediate voltages were 128 and 130, so that the observations were quite regular. Nevertheless, with 656 volts on the first electrode a current can be detected at the second, this in some cases amounting to as much as 10 per cent. of the original. Lime gives an excess of negative, mercury and aluminium phosphate of positive ions, but in each case the currents on the back electrode were practically the same, independently of the sign, while the same ionising agent was used. The saturation curves also present a peculiarity in a large number of cases. The curves become nearly horizontal at about 240 volts, after which they rise again rather rapidly, and finally become flat at about 320 volts. Each of these results is readily explained if we assume the presence of neutral doublets, which are broken up either by collisions or by the action of the field. E. E. F.

846. *Connection between Temperature of the Electrodes and Voltage of the Arc.* **C. D. Child.** (Phys. Rev. 30. pp. 311–321, March, 1910.)—Modern theory leads us to expect that with cooled electrodes a higher p.d. is needed to maintain the arc than with uncooled electrodes, but most of the experimental evidence indicates the opposite conclusion. A *résumé* of the previous experiments is given, and some of them are repeated and certain modifications made. It is shown that cooling the kathode of a carbon arc raises the p.d. by several volts. The increase in the voltage when the anode is cooled is less. It is also shown that the increase in the p.d. between different parts of the arc is approximately proportional to the p.d. existing before the kathode is cooled. A. R.

847. *Bending of Electric Waves.* **J. W. Nicholson.** (Phil. Mag. 19. pp. 485–487, March, 1910.)—It is pointed out that Poincaré has himself noticed the defects in his investigation previously criticised by the author [see Abstract No. 430 (1910)], and made it more nearly accordant with that of the author. The general exponential formula now obtained by Poincaré cannot, however, be accepted for great distances, as in the case of some of the neglected terms of the zonal harmonic series employed, the decrease with increasing orientation from the oscillator is not exponential, and therefore some of the neglected terms may have a sum greater than that of those retained. G. W DE T.

848. *Experiments on the Electrical Oscillations of a Hertz Rectilinear Oscillator.* **G. W. Pierce.** (Amer. Acad., Proc. 45. No. 11. pp. 325–335, March, 1910.)—The wave-length of a long thin, Hertz rectilinear oscillator, stretched parallel to the ground and 10 m. above it, is determined by resonance with a standardised wave-meter. The experiments are carried out inside a building. Oscillators varying in length from 8 to 30 m. are used. It is found that the wave-length is 2·094 times the total length of the oscillator. This is 4·5 per cent. higher than Abraham's theoretical value. The log. decrement per complete oscillation is 0·32. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

849. *Conduction of Electricity.* **J. Koenigsberger** and **K. Schilling.** (Ann. d. Physik, 32. 1. pp. 179–280, April 28, 1910.)—It has been shown experimentally that a minimum of electric resistance exists for various elements and compounds. The experiments were carried out with a Wheatstone bridge arrangement. The existence of a minimum value could be observed in easily attainable temperature intervals. The minimum can be deduced on the electron theory on the assumption of a dissociation of the electrons from the atom or molecule. It has nothing to do with the transformation points or changes of coarseness of structure, since it was shown in the case of large uniform crystals. The transformation points of various solid modifications of elements and compounds show themselves by a bend on the resistance curve. These transformation points are situated at the same temperature at which the magnetisation disappears and the specific heat changes suddenly. In the case of the solid elements, oxides, and sulphides examined the transport of electricity takes place only by means of electrons; this occurs also with some fluid derivatives of the benzene series, and is shown by electrometric and galvanometric investigation of the polarisation, and by chemical analysis of electrolytically separated substances. On the other hand, with solid compounds possessing marked salt, basic, or acid character it takes place by means of ions. On the ground of thermodynamic considerations two formulæ for the resistance of solids with electronic conduction can be drawn up. The first is suited for the case of great heats of dissociation, and is supported by observation. For small heats of dissociation the difference of the specific heats and their change with temperature must be considered. With uniform elements and compounds the law of Ohm holds: unipolar conduction only exists where there is want of uniformity. J. J. S.

850. *Contact Difference of Potential in a Magnetic Field.* **E. P. Adams.** (Phys. Rev. 30. pp. 371–376, March, 1910.)—Gold-zinc, platinum-zinc, and gold-iron combinations were tested in a field of 4800 units. Kelvin's compensation method was employed, and no change could be detected with an arrangement sensitive to 10^{-3} volt. The author discusses the investigation of Posejpal who obtained a change in the contact p.d. for iron and zinc. A. D. R.

851. *Thermoelectric Peculiarities of Metallic Alloys.* **W. Haken.** (Ann. d. Physik, 32. 2. pp. 291–336, May 12, 1910. Extract from Dissertation, Berlin.)—The investigation of the thermoelectric properties of the systems: Te-Sb, Te-Sn, Te-Bi, Te-Pb, Sb-Ag, and Cu-P, gives as a result that these compounds appear on the curves of the thermo-e.m.f.'s distinctly as singular points. The curves give the relation between thermo-e.m.f. and the percentage amount of one of the components of the alloy. The course of the curve between the compounds and the components is a continuous one, and the appearance of mixed crystals is marked by a strong bending on the curve. The determination of the thermo-forces of alloys can thus with advantage be employed in many cases for the support of conclusions drawn from thermal analysis as regards the appearance of compounds, and eventually also of miscibility in the solid condition, since the measurement can be applied directly to the regulus obtained by melting, whilst the determination of the conductivity of most alloys is very difficult on account of their brittleness and the necessity of giving a definite geometric form to the specimens. The thermoelectric properties of the substances can also be used in obtaining the transformation points, as is done by the author in determining the two modifications of Te. The results of the investigation are given in a set of curves, and the thermo-e.m.f. and electric conductivity of the alloys examined are compared in a table. In this it appears that in general the thermo-e.m.f. is higher the lower the conductivity is. For the construction of thermopiles the practical rule follows that metallic compounds should be used when comparatively high values of thermo-e.m.f. and relatively great conductivity are required. It is striking that between constitution and thermo-e.m.f. quite similar relations exist as for electric conductivity, yet there are no simple quantitative relations between both properties; possibly the conductivity for heat plays an intermediate part. J. J. S.

852. *Variations of Contact Potential.* **H. Beil.** (Ann. d. Physik, 31. 5. pp. 849–889, April 5, 1910. Extract from Dissertation, Rostock.)—The determination of the contact potential was made by the compensation method. The contact potential of freshly cleaned zinc plates decreases in general with the time. This decrease is of the order of magnitude of about 0·2 volt in the first half-hour. In the interior of a closed vessel the decrease is lessened, and the more the smaller the vessel is. This action is traced to the influence of water-vapour, and the lessening in a vessel is due to the smaller motion of the air. The variations of contact potential, due to the presence of a neighbouring plate, observed by Pellat, may be explained in the same way as being due to the action of water-vapour. It is probable that H_2O_2 plays an important part in the process of lowering the contact potential. With chemically pure zinc the influence of water-vapour is considerably smaller than with ordinary zinc. CO_2 acts in a way analogous to water-vapour, especially in conjunction with the latter. Copper shows qualitatively the same phenomena as zinc, but only with one-tenth the intensity. An electrostatic field has no action on the contact potential either in dry or moist air, and no influence due to light was observed. Different methods of cleaning the plates give rise to various differing values for the contact potential of zinc, the highest value being given by rubbing with powdered glass. J. J. S.

ALTERNATING CURRENTS AND MAGNETISM.

853. *Moments of the Elementary Magnets of Iron, Nickel, and Magnetite.* **J. Kunz.** (Phys. Rev. 30. pp. 359–370, March, 1910.)—In his development of the electron theory of magnetism, Weiss assumed that every molecule of a ferromagnetic substance is acted upon by the surrounding molecules which produce a uniform field proportional to the intensity of magnetisation at the point considered and coinciding in direction with the direction of magnetisation. The hypothesis of an internal, or molecular, magnetic field is shown by the author of the present paper to lead to results in good agreement with various observed facts. He proceeds to show that this electron theory gives us a means of determining the absolute value of the moment of the molecular magnets of those substances whose internal magnetic field has been determined. He thus obtains $5·15 \times 10^{-20}$, $8·65 \times 10^{-20}$, and $2·02 \times 10^{-20}$ absolute electromagnetic units in the respective cases of Fe, Ni, and magnetite. From these figures he deduces that the molecular magnet of Fe probably contains two atoms, while that of Ni is made up of six atoms. A. D. R.

854. *Chrome Steel Magnets.* **W. Brown.** (Roy. Dublin Soc., Proc. 12. No. 29. pp. 349–358, April, 1910.)—Experiments were made on a series of 18 chrome steel bars of dimension-ratio 38, to determine which percentage of Cr_2 was most suitable for the construction of permanent magnets. The specimens were examined first in a glass-hard, and afterwards in an annealed condition. They were also subjected to mechanical vibration, and the per-

centage loss thus caused in the magnetic moment was measured. The annealing had little effect on the permanent magnetism. The best specimen had the percentage composition C 0·86, Si 1·96, Mn 0·40, Cr 1·96. After magnetisation in a field of 2000 units it had a magnetic moment per gm. of 50 to 51 c.g.s. units, and was little affected by moderate jarring. A. D. R.

855. *Perturbations of Terrestrial Magnetism at Bordeaux.* **A. Nodon.** (Comptes Rendus, 150. pp. 751–753, March 14, 1910.)—By means of a special magnetometer of feeble moment of inertia a series of secular magnetic perturbations of different period to those registered by the usual magnetometer have been detected. In the northern hemisphere the north end of the needle is turned towards the east. After deflection the needle quickly returns to its normal position, and the number of such oscillations may vary from 1 to 4 per sec. The variations appear to be accompanied by changes in the terrestrial electric charge. C. P. B.

REFERENCES.

856. *Atmospheric Electricity.* **H. Benndorf.** (Akad. Wiss. Wien, Sitz. Ber. 118. 2a. pp. 1163–1195, Oct., 1909.)—A mathematical paper dealing with the theory of atmospheric electricity measurements, and especially of registering instruments. Further theory and practical conclusions are to be given in a subsequent paper. A. W.

857. *Complex Resonance in Circuits carrying an Alternating Current.* **A. A. Petrovskij.** (Acad. Sci. St. Pétersbourg, Bull. 4. pp. 319–344, March 1, 1910.)—A mathematical paper unsuitable for abstraction. T. H. P.

858. *The Law of Electromagnetic Induction.* **N. E. Dorsey.** (Electrician, 64. p. 1030, April 1, 1910.)—The author shows that Hering's experiment [Abstract No. 838 (1908)] is in accord with Maxwell's statement of the law of electromagnetic induction. A. R.

859. *Dry Cell Tests.* **F. H. Loveridge.** (Amer. Electrochem. Soc., Trans. 16. pp. 109–118; Discussion, pp. 118–124, 1909.)—Various tests are discussed. The method of running a cell continuously on a fixed resistance is not regarded favourably by the author, who prefers an intermittent test. A number of performance curves are given. W. R. C.

860. *Magnetic Storm of September 25, 1909.* **E. A. Kučinskij.** (Acad. Sci. St. Pétersbourg, Bull. 2. pp. 137–152, Feb. 1, 1910.)—The author gives the data obtained at the Constantine Observatory in Pavlovsk showing the variation of the three elements of the earth's magnetism during the magnetic storm of Sept. 25, 1909, and compares them with those of previous storms. T. H. P.

861. *Magnetic Storms.* **C. Chree.** (Nature, 83. pp. 354–358, May 19, 1910. Discourse delivered at the Royal Inst., March 4, 1910.)—A summary of present knowledge on the subject, illustrated with typical tabular data and records. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

862. *Relation of Surface Tension to the Internal Pressure and to the van der Waals' Constants,* a *and* b. **P. Walden.** (Zeitschr. Phys. Chem. 66. 4. pp. 385–444, May 21, 1909.)—According to Stefan (Wied. Ann. 29. p. 655, 1886), the work required to bring particles from the interior of a liquid to the surface is equal to one-half of the work required to vaporise these particles, or, $(K - p)V = M\lambda/2$, where K is the sum of the internal pressures, p the vapour pressure, V the volume of one molecule of the liquid or M/d, and $M\lambda$ the molecular heat of evaporation. Combination of this equation with that previously given by the author, namely, $M\lambda/V\gamma_\sigma = 3{\cdot}64$ (Zeitschr. Phys. Chem. 65. p. 205, 1908), gives the relation $K/\gamma_\sigma = 1{\cdot}82 = \text{const.}$ . . . (1), that is, for normal (non-associated) liquids at the boiling-point, the ratio of the internal pressure to the surface tension is constant. Two other expressions are given for the internal or surface pressure: (2) $K_s = 196\gamma_\sigma/\log T_\sigma$, T_σ being the absolute boiling-point; combination of this formula with van der Waals' relation, $K = a/V^2$, gives expression (3) $K_s = 424T_\sigma/V_\sigma$, where V_σ represents the molecular volume at the boiling-point T_σ. For a number of non-associated liquids, these three expressions give moderately concordant values for the internal pressure. All associated substances have high internal pressures, that of water being 10,640 atmos.; it is concluded that liquid hydrogen fluoride, for which K = 7300 atmos., may be expected to approach water in solvent and ionising properties. High internal pressures are also possessed by ammonia (4300), sulphuric acid (8900), nitric acid (8850), hydrogen cyanide (8100), glycol (8500), methyl alcohol (8500), formic acid (2700–8800 atmos.) and also all solvents of importance for the study of the electrolysis of non-aqueous solutions, such as alcohols, phenols, aldehydes, acids, nitriles, &c. The greater the internal pressure of a solvent, the greater is its dissociating power and the more effective its action against association between the molecules of the dissolved substance. The author calculates the values a_σ of the constant a of van der Waals' equation at the boiling-point for a number of non-associated liquids by the formula $a_\sigma = 424VT_\sigma$, and compares the values with those of a_k calculated by van der Waals from critical data. A number of other relations are deduced for which the original must be consulted. T. H. P.

863. *Electrical Conductivity in Mixtures of Metals and their Salts.* I. **A. H. W. Aten.** (Zeitschr. Phys. Chem. 66. 6. pp. 641–671, June 8, 1909.)—The major part of the work is really a study of the conductivity of mixtures of $BiCl_3$ with the lower chloride BiCl (compare the two chlorides of gold, $AuCl_3$ and AuCl), as the metallic Bi which dissolves to the extent of about 40 per cent. in the fused salt does not retain the metallic condition, but if added in excess actually separates out as solid BiCl below 320°, or as liquid BiCl above this temperature. The conductivity is as a rule *decreased* by the addition of the metal, but from 280° upwards there is an initial increase to a max. value followed by a rapid decrease of conductivity as more metal

is added. Bismuth chloride, $BiCl_3$, also dissolves to the extent of 1 or 2 per cent. in the molten metal, though it is difficult to say exactly what the nature of the mixture can be. As in the previous case the addition causes a decrease of conductivity. T. M. L.

864. *Use and Abuse of the Ionic Theory.* **G. N. Lewis.** (Science, 30. pp. 1–6, July 2, 1909.)—A well-balanced criticism of the ionic theory, in which attention is called to the common error of applying to concentrated solutions laws and methods which are of such a character as to apply only to solutions of high dilution; to the danger of deducing too much from the additive properties of salt solutions; to the abnormal behaviour of hydrogen and hydroxyl ions in water with the analogous high velocity of methylate ions in methyl alcohol; and, finally, to the complete breakdown of the law of mass-action when applied to strong electrolytes. T. M. L.

REFERENCES.

865. *Microchemical Tests for the Different Varieties of Glass.* **F. Mylius** an **E. Groschuff.** (Zeitschr. Instrumentenk., Beib. 5. pp. 41–45, March 1, 1910. Communication from the Physikal.-Techn. Reichsanstalt.)—The authors give a series of microchemical tests, by means of which the various acids and bases present in colourless glass may be detected and the character of the glass thus ascertained. The uses and chemical nature of a number of different glasses are given. T. H. P.

866. *Characteristics of Dry Cells.* **C. F. Burgess** and **C. Hambuechen.** (Amer. Electrochem. Soc., Trans. 16. pp. 97–106; Discussion, pp. 106–108, 1909.)—The general characteristics of dry cells are discussed, including the materials used as well as the electrical features, chemical action, electrical defects, &c. It is pointed out that the internal resistance of a cell when in use is due not to drying but to partial reduction of the managanese peroxide, the accumulation of insoluble impurities, and the formation of double salts. W. R. C.